# MEMORANDUM

**Date:** **May 13, 2016**

**To:** **File**

**From:** **Clean Water Services**

**Subject:** **Thermal Load Management Plan Package**

The Oregon Department of Environmental Quality (DEQ) renewed the District's watershed-based National Pollutant Discharge Elimination System (NPDES) permit on April 22, 2016. The District submitted a Thermal Load Management Plan (TLMP) in August 2015 as a supporting document for permit renewal. The TLMP summarizes the District's water quality trading program for temperature which consists of flow enhancement and riparian planting activities. Credits from flow enhancement and riparian planting activities are used to offset the thermal load from the District's wastewater treatment facilities (WWTFs). Shortly after the District's submission of the TLMP, in December 2015, the DEQ adopted new rules for Water Quality Trading (OAR 340-039). Additional requirements for water quality trading plans were presented in the new water quality trading rules. The District submitted a Thermal Load Management Plan Summary document in March 2016 that contained the additional elements required for trading plans as specified in the new water quality trading rules including Best Management Practice (BMP) Quality Standards. DEQ incorporated a permit condition into the District's watershed-based NPDES permit that contains key elements from the District's TLMP and TLMP Summary as well as additional requirements, including a credit retirement ratio and an annual target for credit generation.

The District has consolidated the documents that constitute the DEQ-approved water quality trading program. The District's DEQ-approved water quality trading program consists of the following documents:

- Water Quality Trading Conditions from the Watershed-based NPDES Permit
- *Thermal Load Management Plan Summary,* which includes the *BMP Quality Standards* (March 2016)
- *Thermal Load Management Plan* (August 2015)

# Water Quality Trading Conditions from the Watershed-based NPDES Permit

**SCHEDULE A:**
**Waste Discharge Controls and Limitations for Watershed Activities**

iv. Temperature

The permittee shall implement the DEQ-Approved Thermal Load Management Plan and the elements included in Schedule D, Condition 10 to generate thermal credits that meet or exceed the aggregate Thermal Load to Offset (TLO) discharged from the Durham, Rock Creek and Forest Grove treatment facilities. The thermal loads presented in the table below are used to determine the Thermal Loads to Offset (TLO) for each treatment facility that discharges during the low flow period. Compliance with the thermal load limits shall be demonstrated by generating thermal credits that meet or exceed the aggregate Thermal Load to Offset discharged from the Durham, Rock Creek and Forest Grove treatment facilities. (Schedule B of this permit requires the permittee to report [monthly] the credits generated through implementation of its Thermal Load Management Plan.)

For each treatment facility, TLO (kcal/day) = Current Excess Thermal Load (kcal/day) – Allowable Thermal Load (kcal/day), where

Current Excess Thermal Load (Above System Potential) = $Q_{PS} \times \Delta T \times (1000/35.3) \times 86400 \times 5/9$ kcal/day

$\Delta T = T_{PS} - T_{SP}$, degrees F.

$Q_{PS}$ = Treatment plant effluent flow, cfs

$T_{PS}$ = Treatment plant effluent temperature, degrees F.

$T_{SP}$ = System Potential temperature, degrees F. (D001= 64.6°F; R001 = 58.5°F; F001A= 53.1°F)

Other factors: 1000 $kg/m^3$; 35.3 $ft^3/m^3$; 86400 sec/day; 5/9 degrees C/degrees F

**Table A10: Temperature Limitations**

| Outfall Number | Parameter* | Limitation |
|---|---|---|
| D001 | Effluent Temperature | 77° F daily maximum |
| D001 | Allowable Thermal Load** | $2.0 \times 10^7$ kcal/day |
| R001 | Effluent Temperature | 77° F daily maximum |
| R001 | Allowable Thermal Load** | $2.4 \times 10^7$ kcal/day |
| F001A | Effluent Temperature | 77° F daily maximum |
| F001A | Allowable Thermal Load** | $7.0 \times 10^6$ kcal/day |

*The measurement of maximum effluent temperature shall be the maximum 1-hour average temperature.

**The thermal load limits for the Durham, Rock Creek and Forest Grove facilities are based on the 2001 Tualatin sub-basin TMDL. The TMDL focused on the July/August time period as the critical time period for deriving wasteload allocations. The permittee must demonstrate compliance with the thermal load limits by using the thermal credits calculated for this time period. The permittee may use actual effluent flows and temperatures, and actual stream flows to calculate the thermal loads for the Durham, Rock Creek and Forest Grove treatment facilities. The DEQ may reopen and modify or reissue the permit to include revised temperature and thermal load limits based on new information or on new or revised laws, regulations, or policies related to temperature, including revised TMDL provisions for the Tualatin River Basin.

## SCHEDULE B:

## Minimum Monitoring and Reporting Requirements

**Table B7: Durham and Rock Creek AWWTFs Effluent Monitoring**

| Item or Parameter | Time Period | Minimum Frequency | Sample Type/Action | Report |
|---|---|---|---|---|
| Temperature (degrees F) | May-Oct | Daily | Continuous (at minimum hourly) (See Notes e. and f.) | *1)* Maximum<br>*2)* Maximum 7-day moving average |
| Excess Thermal Load (kcal/day) | May-Oct | Daily | Calculation (See Note h.) | Daily Maximum |

**Table B9: Forest Grove and Hillsboro WWTFs Effluent Monitoring**

| Item or Parameter | Time Period | Minimum Frequency | Sample Type/Action | Report |
|---|---|---|---|---|
| Temperature (degrees Celsius) | May-Oct | Daily | Continuous (at minimum hourly) (See note d.) | *1)* Maximum<br>*2)* Maximum 7-day moving average |

**Table B10: Forest Grove Natural Treatment System Monitoring**

| Item or Parameter | Time Period | Minimum Frequency | Sample Type/Action | Report |
|---|---|---|---|---|
| Temperature | May-Oct. | Daily | Continuous (hourly) (See Notes c., d. and e.) | *1)* Maximum daily value<br>*2)* Minimum daily value |
| Excess Thermal Load (kcal/day) | May-Oct | Daily | Calculation (See Note f.) | Daily Maximum |

e. Aggregate Thermal Load to Offset

The permittee must monitor aggregate thermal load to offset and aggregate thermal credits generated in accordance with the table below:

**Table B11: Aggregate Thermal Load to Offset and Aggregate Thermal Credits Generated**

| Item | Time Period | Minimum Frequency | Sample Type/Action | Report |
|---|---|---|---|---|
| Aggregate Thermal Load to Offset[a] | July-August | Monthly | Calculation | Monthly Value |
| Aggregate Thermal Load Credit[b] | July-August | | | |

Notes:

a.) The aggregate thermal load to offset is the combined thermal load to offset from the Durham and Rock Creek AWWTFs and the Forest Grove NTS.

b.) The aggregate thermal load credit is the combined credits from riparian shade plantings and flow augmentation.

## 14. Minimum Reporting Requirements

| Reporting Requirement | Frequency | Due Date (See Note a.) | Report Form (unless otherwise specified in writing) | Submit To: |
|---|---|---|---|---|
| Table B5: Durham and Rock Creek AWWTFs Influent Monitoring<br><br>Table B6: Hillsboro and Forest Grove WWTFs Influent Monitoring<br><br>Table B7: Durham and Rock Creek AWWTFs Effluent Monitoring<br><br>Table B8: Durham AWWTF Wet Weather Outfall (D003) Monitoring (when discharging)<br><br>Table B9: Forest Grove and Hillsboro WWTFs Effluent Monitoring<br><br>Table B10: Forest Grove WWTF Natural Treatment System (when discharging)<br><br>Table B11: Aggregate Thermal Load to Offset and Aggregate Thermal Credits Generated<br><br>Table B22: Hillsboro and Forest Grove WWTFs Transfer Flows | Monthly | 15th day following the completed monitoring period | DEQ-approved Discharge Monitoring Report (DMR) form, electronic and hard copy<br>(See Note c. through e.) | DEQ Regional Office<br>DEQ Water Quality Division, OIS |
| Water Quality Credit Trading - Determination of Thermal Loading and Credits to offset thermal loads from Riparian Area Shading (See Schedule D.10.f.) | Per Occurrence (following first receipt of credit) | 15th day following the completed monitoring period | DEQ-approved Discharge Monitoring Report (DMR) form, electronic and hard copy | DEQ Regional Office<br>DEQ Water Quality Division, OIS |
| Water Quality Credit Trading - Determination of Thermal Loading and Credits to offset thermal loads from Flow Augmentation (See Schedule D.10.f.) | Monthly, for all periods of credit generation; typically July- August | 15th day following the completed monitoring period | DEQ-approved Discharge Monitoring Report (DMR) form, electronic and hard copy | DEQ Regional Office<br>DEQ Water Quality Division, OIS |
| Water Quality Credit Trading Report (See Schedule D.10.g.) | Annually | March 31 | 1 hard copy | DEQ Regional Office |

**10. Water Quality Credit Trading in the Tualatin Basin**

a. Authorization of Credit Trading

The permittee is authorized to use water quality credit trading to comply with the waste discharge limitations in Schedule A provided its credit trading activities comply with the requirements of this section and its Thermal Load Management Plan. The permittee's credit trading activities may not cause a net increase of pollutant load or impair in-stream beneficial uses. In addition, the temperature credit trading activities must be designed to reduce or offset thermal loads, improve stream temperatures, and improve or restore conditions for aquatic species in the Tualatin Basin.

For the purposes of this permit, the term "trading" principally refers to credit trading activities to reduce or offset thermal loads, improve stream temperatures, or improve or restore conditions for aquatic species.

The permittee must submit any program amendment that changes the scope or direction of the trading program to DEQ for public notice and review and DEQ approval. DEQ approval and public review is not required for individual trading agreements provided the agreements are for projects that are consistent with the overall scope of the credit trading program. Any modifications to the permittee's trading program must be consistent with OAR 340-039.

b. Authorized Parameters

i. Temperature

The permittee is authorized to implement their Thermal Load Management Plan as approved by DEQ to generate thermal credits.

c. Credit Trading Program Components

The permittee must implement the DEQ- approved Thermal Load Management Plan (also known as the "trading plan"). The permittee's trading plan includes the following elements as required by OAR 340-039-0025(5).

i. Parameter Authorized for Trading - Temperature.

ii. Trading Baseline – The permittee shall verify that project sites comply with the regulatory requirements described in OAR 340-039-0030(1). Regulatory requirements that must be met to comply with the trading baseline include OAR 629-635 through OAR 629-660 (Forest Practices Act), OAR 603-95 (ODA local water quality management rules), and the permittee's Design and Construction Standards (Clean Water Services Resolution & Order 07-20). Only project sites that are in compliance with baseline regulatory requirements will be considered for the riparian shade program.

iii. Trading Area – Trading activities may be used to offset thermal loading from the permittee's four wastewater treatment facilities. Flow enhancement is implemented in the mainstem Tualatin River and its tributaries, including Gales Creek, East Fork Dairy Creek, West Fork Dairy Creek, and McKay Creek. Riparian shade projects are implemented throughout the Tualatin River watershed. Riparian shade projects support beneficial uses in the Tualatin River watershed including salmonid spawning, rearing, and migration.

iv. Best Management Practices (BMPs) – The permittee shall implement two BMPs: flow augmentation and riparian shade projects. The primary water quality benefit from these BMPs is lower stream temperatures. BMP quality standards for the riparian shade projects include analyzing specific sites for their suitability of the BMP, developing site plans for each riparian shade project, design criteria for individual projects, and ongoing qualitative and quantitative monitoring. BMP quality standards are described in greater detail in the permittee's Thermal Load Management Plan.

v. Trading Ratios – The permittee shall apply a 2:1 ratio for calculating thermal credits generated from its riparian shade projects; that is, the thermal credit is equal to 50% of the actual environmental benefit (shade) generated from the project. The 2:1 ratio is used to account for the time lag between initial planting and shade establishment.

vi. Credits

(1) Quantity and Timing – In addition to the credits generated from existing riparian shade projects, it is expected that the permittee will have to generate an additional 33.4 million kcal/day of thermal credits annually during the five-year permit cycle. This quantity is based on anticipated 2025 design flows for the WWTFs, thermal loads associated with those flows, and implementation of a thermal load reduction strategy. The quantity to be generated may change based on updated information. The permittee must generate the number of thermal credits to offset its actual excess thermal load.

(2) Methods – Thermal credits will be expressed in kcals/day. The estimate of the thermal credits that must be generated is based on current 2025 projected flows at the permittee's WWTFs, the thermal loads associated with those flows, and the implementation of a thermal load reduction strategy.

(3) Duration - Thermal credits generated from the BMPs will be able to be used as long as the BMP is being implemented consistent with the BMP quality standards and the BMP is functioning effectively.

(4) Credit Retirement - At the conclusion of the permit cycle, the permittee shall retire 5% of the credits generated from riparian shade projects during this permit cycle. The 5% value will be based on the credits generated during the permit cycle as documented in the permittee's final annual report for this permit cycle. Permittee may include the value of the retired credits in the estimated shade credits needed for its subsequent permit.

vii. Monitoring

(1) BMP monitoring – Qualitative monitoring will be conducted annually for all riparian shade projects enrolled for thermal credit. Qualitative monitoring will be used to assess overall project health and project phase (transitional, established, or stewardship). Flow augmentation will be monitored using data from stream flow monitoring stations located throughout the Tualatin River watershed.

(2) Water quality benefit monitoring – Following a riparian shade project's initial enrollment for thermal credit, the permittee must conduct quantitative monitoring (shade monitoring) every five years until year 20 to assess the development of the shade producing canopy. The permittee may use a densiometer or remotely sensed datasets, such as LiDAR and aerial photos, to evaluate canopy cover.

viii. Trading Plan Performance Verification – The permittee must use the results of its qualitative and quantitative monitoring to verify the BMPs are functioning as planned. If monitoring indicates that the riparian shade project is not performing as anticipated, the permittee shall take additional steps to improve the project's performance. If these steps do not improve the project's performance, the permittee shall either remove credits associated with the project from its portfolio or recalculate credits based on adjusted expectations.

ix. Tracking and Reporting – Permittee must submit to DEQ annual reports in accordance with OAR 340-039-0017(3) (see Schedule D, Section 10 g, below). Permittee must make the annual reports available to the public by posting the reports to its website.

d. General Provisions for Credit Trading

i. Obtaining credits.

(1) The permittee may obtain credits through contractual trading agreements through market place exchanges, or through collaborative efforts with land or water conservation organizations, government agencies, private parties, or through activities performed by the permittee itself.

ii. Validity of credits.

(1) Credits must be generated from activities that are not already required by statute or rule.

(2) Credits must be generated prior to or during the period they are applied to the permittee's waste discharge limitations in Schedule A except as provided in Schedule D.10.e.iv.

(3) Assurances exist to ensure that credits are generated and will be maintained for the expected duration.

(4) Maintenance plans must be developed for the duration of the credits.

(5) Monitoring plans must be developed and implemented for the activities generating credits to ensure that these activities are functioning as intended.

(6) Credits generated must comply with OAR 340-039-0040.

iii. Duration of credit. The permittee may use credits to comply with its waste discharge limitations in Schedule A for as long as the best management practice is functioning as expected and producing the intended water quality benefits.

iv. Events beyond the permittee's reasonable control.

(1) Damage to a project due to an event beyond the permittee's reasonable control (for example, wildfire, flood, vandalism) is not in and of itself considered a violation of this permit.

(2) If such an event occurs, the permittee must report to DEQ within 90 days of becoming aware of the damage. The report must include the following:

(a) A description of the event, including an assessment of the damage.

(b) A corrective action plan for addressing the damage or replacing the project with an alternative site or sites. Natural restoration and/or active replanting of the site is allowed if continued maintenance is expected to provide a reasonable potential for the long term restoration of the shading function in an ecologically appropriate manner.

(c) Schedule for implementation of the permittee's corrective action plan.

(3) Credits from projects that are damaged due to events beyond the reasonable control of the permittee remain valid provided the permittee demonstrates to DEQ that the sites will be restored or alternative solutions implemented and credits will be generated within a reasonable timeframe.

e. Provisions for Generating Thermal Load Credits

i. Thermal load credits may be generated from the following activities:

(1) Riparian area shading
(2) Receiving stream flow augmentation

ii. Credits must be from activities implemented after the adoption date of the 2001 Tualatin TMDL.

iii. Credits for reducing thermal load must be generated in the trading area as described above in Schedule D, Section 10c.iii.

iv. The permittee may use credits for as long as the credit generation activity is monitored and functioning as described in the approved trading program, unless otherwise specified by this permit or DEQ in writing.

f. Monthly Thermal Credit Reports

The permittee must report to the DEQ by the 15th of each month through Discharge Monitoring Reports the thermal load credits that are generated for the following activities:

i. New riparian area shading – Permittee will report project name, project number, stream length planted, thermal load blocked and thermal credits for each new riparian shade project that is completed within the calendar year. Permittee will report information in the month following the date permittee initially claims credit.

ii. Receiving stream flow augmentation – Permittee must report thermal credits obtained for flow augmentation (July – August of each calendar year).

g. Annual Credit Trading Program Report

The permittee must submit to the DEQ by March 31 an annual report in accordance with OAR 340-039-0017(3). At a minimum, the report must include, for each new riparian shade project that is completed within the calendar year, the project name, project number, stream length planted, thermal load blocked and thermal credits generated.

Clean Water Services

# Thermal Load Management Plan Summary

February 2016

# Thermal Load Management Plan Summary

## Background

Clean Water Services (District) is a county service district that provides wastewater treatment, stormwater management, and watershed enhancement activities to more than 560,000 customers in the urban portion of Washington County. The District has twelve member cities and owns and operates four wastewater treatment facilities (WWTFs). The District's four WWTFs are the Forest Grove WWTF, the Hillsboro WWTF, the Rock Creek Advanced Wastewater Treatment Facility (AWTF), and the Durham AWTF. All four WWTFs discharge to the Tualatin River. The District also implements the municipal separate storm sewer system (MS4) program in the urban portion of the Tualatin River watershed. The four WWTFs and the MS4 program are permitted by the Oregon Department of Environmental Quality (DEQ) under the District's watershed-based National Pollutant Discharge Elimination System (NPDES) permit.

The 2001 Tualatin River Sub-basin Total Maximum Daily Load (TMDL) included strict thermal load allocations for the Rock Creek and Durham AWTFs. The District explored several technology and discharge based alternatives to meet these allocations. The District concluded that the technology based alternatives were resource intensive, cost prohibitive, and would do little to improve watershed health; the discharge based alternatives were also cost prohibitive and would further exacerbate water quality problems by reducing base flows in the Tualatin River. Instead, the District selected an approach to reduce the thermal load from the AWTFs where feasible and implemented a water quality trading program to offset the remaining thermal load from the AWTFs. The thermal waste load allocations from the 2001 Tualatin River Sub-basin TMDL were incorporated into the District's 2004 watershed-based NPDES permit; the watershed-based NPDES permit also included provisions to develop and implement a Temperature Management Plan (TMP) to offset the thermal load from its AWTFs. Since 2004, the District has successfully implemented a temperature trading program as outlined in its TMP to offset thermal loads from the AWTFs.

In 2009, DEQ developed an Internal Management Directive (IMD) for water quality trading programs (WQ Trading IMD) and subsequently updated it in 2012. As part of its permit renewal, the District updated its TMP (now called Thermal Load Management Plan (TLMP)) and submitted it to DEQ in August 2015. The TLMP reflected several enhancements that were made to the trading program over more than a decade of implementation and was prepared in accordance with the 2012 WQ Trading IMD. The TLMP was among the documents that were made available during the public comment period for the District's draft watershed-based NPDES Permit, which ended on December 2, 2015. Shortly thereafter, on December 10, 2015, DEQ adopted new rules on the Water Quality Trading Program (Oregon Administrative Rules (OAR) 340-039). OAR 340-039 specifies the key elements of a water quality trading plan. The District is providing a summary of its TLMP to address the key elements of the trading plan specified in OAR 340-039. The District is also using this opportunity to update certain elements of the TLMP to reflect the new trading rules.

The following is a brief summary of the key elements of the District's TLMP. Refer to the TLMP for additional details.

## 1) Parameters

The District is proposing to offset excess thermal loads (i.e., temperature) from the Rock Creek AWTF, Durham AWTF, and Forest Grove WWTF with thermal credits from water quality trading activities. The Hillsboro WWTF does not currently discharge to the Tualatin River during the dry season (~May to October).

## 2) Trading Area

Thermal credits from water quality trading activities are generated by conducting flow enhancement in the mainstem Tualatin River and key tributaries. Thermal credits are also generated by conducting riparian shade planting in the Tualatin River watershed. The District's water quality trading activities and project prioritization criteria are geared towards supporting beneficial uses in the Tualatin River watershed including salmonid spawning, rearing and migration.

## 3) Best Management Practices

Flow enhancement and riparian shade planting programs are the management practices that the District implements to offset thermal loads from the WWTFs. These management practices are discussed below.

### Flow Enhancement

The District releases stored water from Hagg Lake and Barney Reservoir to the Tualatin River during the summer and fall periods. The District also releases stored water into key tributaries of the Tualatin River including Gales Creek, East Fork Dairy Creek, West Fork Dairy Creek, and McKay Creek. Water quality benefits from flow enhancement include lower stream temperature as a result of the additional stream flow, reduced residence time, and cold water that is released from the reservoirs.

The District used the DEQ Heat Source model from the 2001 Tualatin River Sub-basin TMDL to develop empirical equations to calculate temperature reduction immediately above the Rock Creek, Durham, and Forest Grove WWTFs as a function of stored water releases and stream flow conditions. The equations for calculating temperature changes due to flow enhancement above each WWTF are presented below:

Temperature change above the Rock Creek AWTF (°C):

$$\Delta T = (5.014)\left[1 - e^{\left(\frac{Flow\ Enhancement}{Farmington\ Flow - Rock\ Creek\ AWTF}\right)}\right]$$

Where:

*ΔT = temperature change above the Rock Creek AWTF (°C)*
*Flow Enhancement = CWS Release from Hagg Lake + CWS Release from Barney Reservoir (cfs)*
*Farmington Flow = Tualatin River Flow at Farmington Gage (cfs)*
*Rock Creek AWTF = Rock Creek AWTF Effluent Flow (cfs)*

Temperature change above the Durham AWTF (°C):

$$\Delta T = (-0.02636)\frac{Flow\ Enhancement}{1 + e^{[(-0.03941)(Farmington\ Flow - 145.5)]}}$$

Where:

*ΔT = temperature change above the Durham AWTF (°C)*
*Flow Enhancement = CWS Release from Hagg Lake + CWS Release from Barney Reservoir (cfs)*
*Farmington Flow = Tualatin River Flow at Farmington Gage (cfs)*

Temperature change above the Forest Grove WWTF (°C):

$$\Delta T = (0.2349)(Flow\ Enhancement)^2 - 1.2906(Flow\ Enhancement) - 0.0838$$

Where:

*$\Delta T$ = temperature change above the Forest Grove WWTF (°C)*
*Flow Enhancement = Flow Enhancement as Percentage of Flow Upstream of the Forest Grove WWTF (%) (($^{\text{CWS release from Hagg Lake and Barney Reservoir}}/_{\text{Tualatin River flow above Forest Grove}}$)*100)*

The following equation is used to calculate thermal credits from flow enhancement at the Rock Creek, Durham, and Forest Grove WWTFs. Note that the temperature change above each WWTF (calculated using the equations above) is shown in the following equation as $\Delta T_{FlowAug}$.

$$H_{Flow\ Aug} = \frac{1\ kcal}{1\ kg°C}\ x\ Q_{River}\ x\ \frac{1\ m^3}{35.3\ ft^3}\ x\ \frac{1000\ kg}{1\ m^3}\ x\ \frac{86400\ sec}{1\ day}\ x\ \Delta T_{FlowAug}$$

Where:

*$H_{FlowAug}$ = the thermal credit from flow enhancement activities*
*For the Rock Creek AWTF, $Q_{River}$= Tualatin River Flow at the Farmington Gage – Rock Creek AWTF flow (cfs)*
*For the Durham AWTF, $Q_{River}$ = Tualatin River Flow at the Farmington Gage (cfs)*
*For the Forest Grove WWTF, $Q_{River}$ = Tualatin River Flow at the Golf Course Road Gage – Forest Grove WWTF flow (cfs)*
*$\Delta T_{FlowAug}$ = temperature change above each WWTF calculated using the equations specified above*

Consistent with the 2001 Tualatin River Sub-basin TMDL, the time period for credit calculations are the months of July and August because it is the time of year when river temperatures are warmest and therefore most likely to exceed the temperature criterion. Even though the flow enhancement credit generation period is limited to the months of July and August, the District continues its stored water releases from the two reservoirs through September, October, and at times into early November, until the onset of the high flow period.

## Riparian Shade

The riparian shade program is the other key strategy that the District utilizes to offset the thermal load from its WWTFs. As noted in the 2001 Tualatin River Sub-basin TMDL, solar radiation is a significant component of the overall thermal energy input into the Tualatin River watershed. Riparian shade prevents streams from heating by blocking solar radiation (i.e., sunlight) that might otherwise increase water temperatures.

Riparian project prioritization is conducted at the landscape, program, and project scale. Prioritization criteria include presence of existing riparian vegetation, the potential for cold water fish habitat enhancement, aquatic and terrestrial habitat connectivity, the proximity of projects to other natural/conservation areas and to existing projects, and the potential for vegetation to filter sediment and nutrients from agricultural practices or urban runoff.

The District implements a riparian shade program that consists of a Capital Program and landowner incentive programs.

Riparian shade projects implemented under the District's Capital Program mostly occur on public lands. Project activities under this program include site preparation activities, planting, monitoring, and maintenance. Additional project enhancement activities such as channel reconfiguration, large wood placement, off-channel habitat creation, and wetland enhancement are performed on a site-specific basis to improve a broader range of site water quality and ecological functions.

The District also funds landowner incentive programs that enroll agricultural lands in riparian shade programs. The landowner incentive programs are implemented by the Tualatin Soil and Water Conservation District (SWCD) in coordination with the Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) for Washington County. Current landowner incentive programs include the following:

- Enhanced Conservation Reserve Enhancement Program (ECREP), which establishes native trees and shrubs along priority reaches of the Tualatin River and its tributaries to increase riparian shade.
- Vegetated Buffer Areas for Conservation (VEGBAC), which provides incentives for rural landowners to plant native trees and shrubs along stream corridors within portions of Washington and Multnomah Counties in the Tualatin River watershed. VEGBAC offers a restoration alternative to landowners who either do not qualify for ECREP or prefer more flexibility.

A site plan is prepared for each riparian shade project. The site plan contains a map showing the project area and water resources, a schedule and timeline for planting, site preparation protocols, a description of planting goals, and measures to control non-native species, invasive species and damage from wildlife.

Through its experience, the District found that site preparation is essential to rapid and cost effective achievement of planting goals and objectives. Site preparation activities typically include mechanical and chemical control of non-native invasive species, including Himalayan blackberry and reed canary grass, and seeding with native grasses to provide both cover and weed competition. Once the site is prepared, planting plans are developed based on soil type, moisture, exposure, and reference information from nearby native plant communities. Plant types (whether containerized, plug, bare root or pole cutting) are selected depending on site conditions, season, availability and cost. The District conducts high density plantings (~2,500 stems per acre) to provide rapid cover and successful competition from weeds and wildlife, and to reflect reference site conditions.

The District uses a component of the DEQ Heat Source temperature model called Shade-A-Lator to perform shade calculations. The model uses site-specific data including stream length and width, stream aspect, incision, canopy density, riparian vegetation width and height to determine the effective shade, which is a measure of the amount of sunlight blocked by riparian vegetation. The July/August time period is used to calculate the thermal load blocked by riparian vegetation. This is consistent with the 2001 Tualatin River Sub-basin TMDL and corresponds to the time of the year when river temperatures are warmest and most likely to exceed the temperature criterion.

## 4) Trading Baseline

Riparian shade projects under the District's TLMP are implemented in rural and urban areas of the watershed. In rural areas, agricultural landowners are required to protect riparian areas under the local water quality management rules developed by the Oregon Department of Agriculture (also known as Senate Bill (SB) 1010). In urban areas, property developers are required to protect riparian areas under the District's Design and Construction Standards. Project sites that are in compliance with applicable rules governing riparian areas will be considered in the riparian shade program. Because project sites are in compliance with applicable rules, existing vegetation at the project site is used to define baseline conditions for calculating thermal credits. Baseline conditions for calculating thermal credits are determined at project initiation prior to taking credit.

## 5) Trading Ratios

The difference between the thermal load blocked after project implementation (with a 20-year shade establishment period) and the thermal load blocked with existing vegetation represents the reduction in thermal load (i.e., environmental benefit) associated with the riparian shade project. To calculate thermal credit, a trading ratio is applied to the environmental benefit associated with the riparian shade project. The District applies a 2:1 trading ratio for calculating thermal credit (i.e., the thermal credit is equal to 50% of the environmental benefit associated with the project) for all projects. This means that twice as much thermal load will be blocked than is needed to offset the thermal load from the WWTFs. The trading ratio was conceptually derived as the amount of thermal load that would be offset by riparian shade which would be equivalent to the amount of thermal load discharged over a 20-year period. The 20-year period was used to define the time it takes for riparian plantings to generate effective shade. As the riparian shade matures beyond 20-years even greater shade may be generated.

The trading ratio is primarily used to account for the time lag between initial planting and shade establishment. While a 20-year shade establishment period was envisioned in the TMP, the District's focus on conducting riparian shade projects on narrow, tributary streams has resulted in a much shorter period for establishing effective shade. From 2004–2014, the District has implemented 98 riparian shade projects. Sixty-nine of the 98 projects (70%) have stream widths of ≤20 feet; ninety-two of the 98 projects (94%) have wetted stream widths of ≤50 feet; and the median stream width for the projects was < 12 feet. Field monitoring of shade at the riparian shade projects shows that a high level of riparian shade is provided within 5 years at many sites. Recognizing the shorter time needed to shade narrower streams, the TMP allowed a 1:1 trading ratio for narrower, high priority streams. Although the District continues to select priority streams, the District did not utilize the 1:1 trading ratio for its riparian shade projects; all projects were credited using the 2:1 trading ratio. The District has also utilized light detection and ranging (LiDAR) to measure tree height and shading on select projects. The LiDAR data shows that the tree growth rate is equivalent or greater than the 20 year shade establishment period specified in the TMP. Additionally, the District intends to generate the necessary thermal credits to offset growth related increases in thermal load from the WWTFs before the anticipated growth occurs further reducing the shade establishment period. Thus, the District's focus on narrow tributary streams where effective shade can be developed quickly, along with its strategy to develop thermal credits before they are needed, enables the District to reduce the time between initial planting and shade establishment to much less than the 20 years.

The District also undertakes significant steps to improve the success of its riparian shade program; these include developing a variety of land stewardship agreements, designing ecologically-appropriate planting plans, extending site preparation, conducting high density riparian shade plantings, implementing robust monitoring and maintenance programs, and conducting inter-planting as necessary to ensure project functions are achieved.

For the reasons noted above, the 2:1 trading ratio used by the District to determine thermal credits is conservative. As more information becomes available in the future and DEQ develops additional guidance, the District may modify the trading ratio to provide incentives for narrow streams and for stream enhancement activities.

## 6) Credits

The District's implementation strategy consists of reducing the thermal load from the WWTFs, and continuing to implement a water quality trading program to offset any additional thermal load from the WWTFs.

The following equations are used to calculate the anticipated thermal load from the WWTFs based on design year 2025 flow conditions, the anticipated reduction in thermal load associated with the implementation of thermal load reduction strategies, the allowable thermal load based on the 2001 Tualatin River Sub-basin TMDL and the thermal credits necessary to offset the remaining thermal load from the WWTFs.

**Thermal load from WWTFs**

In accordance with the 2001 Tualatin River Sub-basin TMDL, the thermal load contributed by each WWTF is defined as the amount of thermal energy gained by the Tualatin River from the WWTF effluent. The thermal energy gained by the river is obtained by assuming that the effluent mixes completely within the mixing zone. The temperature change of the river can be calculated using the following equation:

$$\Delta T_{MixZone+effluent} = \frac{Q_{MixZone}T_{SysPot} + Q_{effluent}T_{effluent}}{Q_{MixZone} + Q_{effluent}} - T_{SysPot}$$

*Where:*

$\Delta T_{MixZone+effluent}$ = *the temperature change in the Tualatin River (ºC)*

$Q_{MixZone}$ = *the mixing zone flow which equals one quarter of the median daily river flow just upstream of the outfall; and*

$T_{SysPot}$ = *the system potential river temperature just upstream of the outfall (11.1°C for Forest Grove; 14.7°C for Rock Creek; and 18.1°C for Durham)*

The thermal load from each WWTF is calculated using the following equation:

$$H_{WWTP} = \frac{1\ kcal}{1\ kg°C}\ x\ \left(Q_{MixZone} + Q_{effluent}\right)\ x\ \frac{1\ m^3}{35.3\ ft^3}\ x\ \frac{1000\ kg}{1\ m^3}\ x\ \frac{86400\ sec}{1\ day}\ x\ \Delta T_{MixZone+effluent}$$

*Where:*

$H_{WWTP}$ = *the thermal load discharged from the WWTF*

$Q_{MixZone}$+ $Q_{effluent}$ = *flow in the mixing zone below the outfall (cfs); and*

$\Delta T_{MixZone+effluent}$ = *the temperature change in the Tualatin River (ºC) calculated as shown above*

**Thermal Load Reduction Strategies**

The District's thermal load reduction strategies include the construction of a natural treatment system adjacent to the Forest Grove WWTF and the expanded use of recycled water. The reduction in thermal load from the implementation of these strategies is calculated as follows.

*Forest Grove Natural Treatment System*

Currently, the Forest Grove and Hillsboro WWTFs transfer wastewater through twin, 24-inch pipelines to the Rock Creek AWTF for treatment and discharge during the dry season. The District is proposing to provide advanced secondary treatment at the Forest Grove WWTF during the dry season and direct the treated wastewater through a 95-acre natural treatment system (NTS) in Forest Grove for further treatment prior to discharge to the Tualatin River.

Effluent temperatures from the Forest Grove NTS are anticipated to be about 3.8°C cooler in July and 5.6°C cooler in August on a monthly average basis compared to the Rock Creek AWTF. These temperature differences along with the year 2025 design flow (6.3 mgd) were used to calculate the thermal load reduction associated with the Forest Grove NTS using the following equation:

$$H_{TR\ FGNTS} = (1kcal/1kg°C)x\ (Q_{FG\ NTS})\ x\ \left(\frac{1m3}{35.3ft^3}\right) x \left(\frac{1000kg}{1m^3}\right) x \left(\frac{86400sec}{1day}\right) x\ (\Delta T)$$

*Where:*

$H_{TR\ FG\ NTS}$ *= the thermal load reduction associated with the Forest Grove NTS (kcal/day);*
$Q_{FG\ NTS}$ *= the 2025 design flow associated with the Forest Grove NTS (cfs); and*
$\Delta T$ *= the anticipated temperature reduction associated with the Forest Grove NTS (°C)*

*Recycled Water Use*

The District anticipates implementing a 1-mgd Class A recycled water use program at both the Rock Creek and Durham AWTFs. Because recycled water use represents a direct reduction in the thermal load discharged to the Tualatin River, this represents a 79 million kcal/day reduction in the thermal load at each facility. The equation for calculating the thermal load reduction associated with a recycled water use program is as follows:

$$H_{TR\ RW} = (1kcal/1kg°C)x\ (Q_{RW})\ x\ \left(\frac{1m3}{35.3ft^3}\right) x \left(\frac{1000kg}{1m^3}\right) x \left(\frac{86400sec}{1day}\right) x\ (T)$$

*Where:*

$H_{TR\ RW}$ *=the thermal load reduction associated with a recycled water program (kcal/day);*
$Q_{RW}$ *= the flow associated with the recycled water program (cfs); and*
$T$ *= the WWTF effluent temperature (°C)*

**Allowable Thermal Load**

In accordance with the 2001 Tualatin River Sub-basin TMDL, the allowable thermal load (i.e., wasteload allocation) is based on "no measurable change above system potential temperature." Measurable change is defined as no more than a 0.25ºF change in temperature at the edge of the mixing zone. The allowable thermal load is expressed as a negative number because it is an allowance that is subtracted from the thermal load to offset at each WWTF.

$$H_{WWTF\ Allowance} = (1kcal/1kg°C)x\ (Q_{mixzone} + Q_{effluent})\ x\ \left(\frac{1m3}{35.3ft^3}\right) x \left(\frac{1000kg}{1m^3}\right) x \left(\frac{86400sec}{1day}\right) x\ (0.25°F)\ x\ (5°C/9°F)$$

*Where:*

$H_{WWTF\ Allowance}$ *= the thermal load allocated under the 2001 Tualatin Sub-basin TMDL (kcal/day); and*
$Q_{Mixzone} + Q_{effluent}$ *= flow in the mixing zone below the discharge location (cfs)*

**Thermal Credits**

From 2004-2014, the District has implemented a total of 98 riparian shade projects. Fifty projects have been implemented in the urban portion of the Tualatin River watershed and have resulted in the restoration of 20.6 stream miles of riparian vegetation. Forty-eight projects have been implemented in the rural portion of the Tualatin River watershed and have resulted in the restoration of 25.7 stream miles of riparian vegetation. The District has generated 400 million kcal/day of thermal credits with the implementation of these riparian shade projects. As discussed below, the District conducts routine monitoring at project sites to ensure project success. Since the riparian shade projects continue to provide shade, the thermal credits from the projects continue to be available for use in offsetting the thermal loads from the WWTFs.

The District also released an average of 35.8 cfs of stored water annually from 2004-2014. Flow enhancement activities have generated an average of 511 million kcal/day of credits at the Rock Creek AWTF and 392 million kcal/day of credits at the Durham AWTF during this period. Anticipated credits from flow enhancement were calculated to be 111 million kcal/day at the Forest Grove WWTF based on the 2004-2014 average release rate.

**Summary**
The following equations were used to determine the thermal load to offset and the additional credits needed based on year 2025 flow conditions at the Rock Creek, Durham, and Forest Grove WWTFs:

$$\begin{aligned} &\textit{Thermal load to Offset} \\ &\quad = \textit{Thermal load from WWTFs} - \textit{Thermal Load Reduction at WWTFs} \\ &\quad - \textit{Allowable Thermal Load} \end{aligned}$$

$$\begin{aligned} &\textit{Additional Credits for } 2025 \textit{ conditions} \\ &\quad = \textit{Thermal load to Offset} - \textit{Credits from Ongoing Flow Enhancement} \\ &\quad - \textit{Credits from Riparian Shade generated from } 2004 - 2014 \end{aligned}$$

The following table presents the anticipated 2025 design flows for each WWTF , the thermal loads from the WWTFs based on 2025 flows, the thermal load reduction based on the implementation of the strategies noted above, the thermal loads to offset, and the additional credits needed based on 2025 design flows.

**Table 2: Thermal Loads and Credits (2025 conditions)**
(based on 2025 conditions with lower growth rate)

| Facility | 2025 Flows (MGD) | Thermal Load | Thermal Load Reduction | Allowable Thermal Load (2001 TMDL) | Thermal Load to Offset | Flow Enhancement Credit (on-going) | Riparian Shade Credits (2004-14) | Additional Credits to meet 2025 conditions | Riparian Program Scale (miles/year) |
|---|---|---|---|---|---|---|---|---|---|
| Forest Grove | 6.1 | 180 | 0 | -8 | 172 | -111 | --- | --- | --- |
| Rock Creek | 42.3 | 1438 | -192 | -32 | 1213 | -511 | --- | --- | --- |
| Durham | 23.5 | 392 | -79 | -28 | 363 | -392 | --- | --- | --- |
| Cumulative Totals | 71.9 | 2009 | -271 | -69 | 1748 | -1014 | -400 | 334 | 3.3 |
| Except as noted, all values in million kcal/day | | | | | | | | | |

The District estimates that the thermal load reduction strategies will result in a 271 million kcals/day total thermal load reduction at the three WWTFs. Flow enhancement activities are estimated to generate 1,014 million kcals/day of thermal credit based on an 11-year average (2004-2014); the District has generated 400 million kcal/day of thermal credits from riparian shade projects through 2014. With the projected growth rate, the District will need to obtain an additional 334 million kcal/day of thermal credit by 2025 to offset anticipated growth-related increases of thermal load from the WWTFs for 2025 flow conditions. This equates to approximately 3.3 miles per year of additional riparian shade planting in the watershed over the next 10 years.

The projections in Table 1 above are based on an average pre-recession growth rate. The District conducted a similar assessment based on a higher growth rate. The results of the assessment are presented in the TLMP. It is likely that the average pre-recession growth rate provides a better estimate of the future thermal loads. Thus, the District is anticipating that it will need an additional 334 million kcal/day of thermal credit over the next 10 years. The District will continue to generate thermal credits to offset any increase in thermal loads from the WWTFs. At this stage, the District will target generating an additional 33.4 million kcal/day of thermal credit per year through flow enhancement and riparian shading. Note that the District also anticipates reducing thermal loads discharged from the WWTFs through actions such as recycled water use and industrial pretreatment controls. The thermal credit targets will be reviewed and updated in the annual report based on actual thermal load growth in the service area.

**Credit Duration**

Sites are eligible for credit enrollment after initial planting has been completed. Credits are effective as long as the ecological functions (i.e., shade) are documented and sustained.

## 7) Monitoring and Verification

**Flow Enhancement Program Monitoring**

The District, in collaboration with its partner agencies, operates 19 stream flow monitoring stations in the watershed. Many of these monitoring stations provide near real-time flow data in the Tualatin River and key tributaries. The District uses this information to manage its stored water releases and to ensure that stored water releases are enhancing stream flow.

**Riparian Shade Program Monitoring**

At each riparian shade planting project, the District conducts baseline, routine, and shade monitoring. These elements are described below:

*Baseline Monitoring*

Baseline conditions are assessed to serve as a benchmark for calculating the reduction in thermal load associated with the implementation of the riparian shade project. Baseline monitoring is conducted prior to initial planting at the project site. The District documents existing vegetation and other site characteristics (e.g., stream aspect, wetted width, and incision) by conducting field measurements and through the use of remotely sensed datasets, such as LiDAR and aerial photos.

*Routine Monitoring*

The District conducts qualitative and quantitative monitoring at all riparian planting projects that are enrolled for thermal credit. Typically, monitoring is conducted during early fall prior to leaf drop. Site assessment reports document site conditions and include site specific management actions.

Qualitative monitoring is conducted on an annual basis and is used to assess overall project health and project phase. The District implements a functional component-based assessment process to determine if a riparian planting project is in a transitional, established, or stewardship phase. This assessment approach assists in determining the necessary level of ongoing maintenance needed for riparian planting projects (e.g., inter-planting, seeding, weed control, herbivore protections) and project phase. This assessment methodology is designed to mimic the dynamic nature of riparian planting projects as they mature from initial plantings to stable riparian ecosystems. Quantitative monitoring is conducted biennially and includes information regarding native tree and shrub counts, species composition, stem density, and riparian structure (i.e., canopy).

Data collected during qualitative and quantitative monitoring is used in conjunction with function-based success criteria to gauge the success of a project. Function-based success criteria are developed from appropriate reference site monitoring and data analysis. Success criteria were developed for the following components: species composition (both woody and herbaceous, native and non-native), density (trees and shrubs), structure (overstory, understory, and groundcover), and riparian shade.

*Shade Monitoring*

Shade is monitored at all project sites to assess the development of shade-producing canopy. Shade monitoring occurs five years following initial enrollment for thermal credit and every five years thereafter until year twenty. The District will either use a densiometer or remotely sensed datasets, such as LiDAR and aerial photos, to evaluate canopy cover.

## 8) Tracking and Reporting

A site assessment report is prepared for each site and is used to document site conditions, identify management actions taken, and to identify proposed actions for the following year. Each site assessment report contains project specific information including project location, acreage, the initial planting year, the year when thermal credit was taken, and the stream length associated with the project. Site assessment reports also contain information regarding each plant community (e.g., riparian forest, forested wetland, upland forest, scrub-shrub) within a project. This information contains a list of categorized plant species, stem densities, and the phase of each plant community.

The District maintains the following information for each riparian shade project: project description, site plan, thermal credit calculations (including thermal load blocked by baseline conditions, the anticipated thermal load blocked by enhanced vegetation, and the thermal credits from each riparian planting project), and site assessment reports.

The District will report the thermal credits that are generated from its on-going flow enhancement activities and new riparian shade planting projects during the months of July and August in the monthly Discharge Monitoring Reports. On an annual basis, the District will submit a report specifying the actions taken to reduce thermal loads from the WWTFs, the thermal loads to offset, the thermal credits generated from water quality trading activities, and the net thermal load to the Tualatin River watershed. The annual report of credit trading activities will be uploaded onto the District's website and made available to the public.

## 9) Adaptive Management

Adaptive management is a key component of the District's riparian shade program. The District's current riparian shade program has evolved over the last decade through the implementation of adaptive management. For example, the District has found that site preparation is essential to rapid achievement of planting goals and objectives. The District conducts extended site preparation activities that last up to two years and include the removal of non-native invasive species, including Himalayan blackberry and reed canary grass, and seeding with native grasses to provide both cover and weed competition. The District has also found that high density planting provide rapid cover and successful competition from weeds and herbivores. The District's approach utilizes high density plantings at all its riparian shade project sites. The District found that establishing defensible ecological and physical boundaries well beyond those needed to generate thermal credits reduce edge effects, and increase the resiliency and likelihood of project success. The District has incorporated a number of such strategies into its riparian shade program through an adaptive management approach.

The District also implements an adaptive management strategy at the project scale because natural processes can alter the initial actions taken at project sites. For example, recolonization by beavers and the creation of beaver ponds result in broad ecological benefits including an improved riparian structure and canopy. The District recognizes that forcing project sites to develop pre-ordained attributes that conflict with natural ecological processes occurring at the site can limit broader ecological benefits. As a result, the District employs adaptive management strategies to address challenges and opportunities that arise at each site.

Additionally, the District implements a robust monitoring and maintenance program and conducts inter-planting as necessary to ensure project functions are achieved. The District may adjust the credits based on project functionality or remove the project and associated thermal credits from its portfolio of riparian shade projects if the project is unsuccessful. If necessary, the District will substitute other non-credited (i.e., reserve) project sites to its portfolio of riparian shade projects.

## 10) Additional Elements

**Public conservation funds**

The District utilizes a collaborative partnership-based approach to implement the riparian shade planting program. This approach enables the District and its partners to generate greater environmental benefits than those possible through individual efforts. These actions go well beyond providing shade. The District's approach encourages broader landscape restoration to simultaneously achieve multiple objectives including nutrient reduction, integrated pest management, erosion control, increased channel complexity, wider stream buffers, floodplain access, wetland restoration, and improved irrigation efficiency. The partners that may provide public conservation funds include NRCS, FSA, Metro, and others. Where public conservations funds are used, the District will seek credit based on the District's contribution to credit generating activities. Credit generating activities for riparian shade programs would include site preparation, planting, monitoring, and maintenance. For the projects where public conservation funds are used, the District will demonstrate in the annual report that the thermal credits for riparian shade projects that are being claimed are based on the District's contribution towards credit generating activities.

**Ecological benefits**

The District's trading program supports numerous ecosystem benefits beyond temperature benefits. The ecosystem benefits of riparian shading activities may include improved stream functions (e.g., floodplain roughness, bank stabilization, peak flow attenuation, habitat creation), increased diversity of aquatic and terrestrial plant and animal species, filtering of stormwater runoff, and improved water quality. The increased complexity of structure and diversity of restored riparian forests and scrub-shrub wetlands support many important ecosystem functions for the aquatic environment. One example of this is the colonization of some stream reaches by beavers, a keystone species for stream function in the basin. By raising the water table, beavers promote floodplain wetlands with enhanced plant, animal, and geomorphic diversity in comparison to the original simplified stream channel. These features and the resultant geomorphic complexity enhance fish habitat quality and may also provide cold water refuges. Furthermore, the enhancement of riparian areas within and outside the District's service area improves the overall health of the Tualatin River watershed and creates partnerships with positive outcomes for water quality.

The District's release of stored water also provides multiple ecosystem benefits. Flow enhancement provides cooling effects, buffers against temperature changes, and results in higher dissolved oxygen levels to support aquatic life. The release of stored water, along with the release of the highly treated discharges from the District's Rock Creek and Durham AWTFs, provides a sustainable base flow to the mainstem Tualatin River during the dry season.

## Appendix

### Appendix A: BMP Quality Standards

# Appendix A: BMP Quality Standards

DEQ's trading rules require that BMPs eligible for credit generation must be quantifiable and have BMP quality standards. A BMP quality standard includes information necessary to ensure that the appropriate BMP is selected for a trading project and properly implemented. This appendix describes elements of the District's thermal load management program that address BMP quality standards. Note that most elements of the BMP quality standards are already described in the District's 2015 Thermal Load Management Plan (TLMP) and in the TLMP Summary. This document provides a brief response to the BMP quality standard elements specified by DEQ and references specific chapters of the TLMP for additional details.

A BMP quality standard should include the following elements:

i. A description of the practice and pollutant sources addressed by the BMP;
*The District is proposing to offset thermal loads (i.e., temperature) from the Rock Creek AWTF, Durham AWTF, and Forest Grove WWTF with thermal credits from water quality trading activities. Thermal credits from water quality trading activities are generated by conducting flow enhancement in the mainstem Tualatin River and key tributaries. Thermal credits are also generated by conducting riparian shade planting in the Tualatin River watershed. The practices and pollutant sources are discussed in the District's 2015 TLMP. Chapter 2, Alternatives Analysis, discusses the pollutant sources addressed by the BMPs; Chapter 4, Flow Enhancement, and Chapter 5, Riparian Shade Program Framework, discuss the management practices that the District implements to offset thermal loads from the WWTFs.*

ii. A quantitative description of the BMP's effectiveness at reducing the pollutant;
*Flow enhancement and riparian shade planting are effective management practices for addressing temperature issues in the Tualatin River watershed. The importance of these management practices is discussed in the 2001 Tualatin River Subbasin TMDL and the District's TLMP. Chapter 4 of the TLMP, which contains a discussion of the flow enhancement program, presents empirical equations based on the 2001 Tualatin River Subbasin TMDL that are used to quantify the benefits of flow enhancement. Chapter 5 contains a discussion of the riparian shade program and the DEQ Shad-A-Lator model, which is used to quantify benefits from riparian shade projects.*

iii. Suitability of the BMP for different situations and when it should be used, including eligible land uses, site conditions, practices, or locations in watersheds where BMPs are applicable;
*For the flow enhancement program, the District releases stored water from Hagg Lake and Barney Reservoir to the Tualatin River and key tributaries during the summer and fall. The time period of interest is the months of July and August because it is the time of year when river temperatures are warmest. Note that the District continues its stored water releases from the two reservoirs through September, October, and at times into early November, until the onset of the high flow period. Thermal benefits from flow enhancement are derived from the additional stream flow, reduced residence time, and colder water that is released from the reservoirs. Additional information regarding the District's flow enhancement program is presented in Chapter 4 of the TLMP.*

*For the District's riparian shade program, riparian plant communities are selected based on site conditions, including soil type and hydrology (Table 1). Prioritization criteria for project locations include the presence of existing riparian vegetation, the potential for cold water fish habitat enhancement, aquatic and terrestrial habitat connectivity, the proximity of projects to* *other natural/conservation areas and to existing projects, and the potential for vegetation to filter sediment and nutrients from agricultural practices or urban runoff.*

*A site plan is prepared for each riparian shade project. The site plan contains a map showing the project area and water resources, a description of the planting goals and customized planting plan based on site conditions, a schedule and timeline for planting, site preparation protocols, and measures to control non-native species, invasive species and damage from wildlife. Because of the dynamic nature of riparian shade projects and the uniqueness of each site, adaptive management strategies are used to address the challenges and opportunities that arise at each site. Additional details regarding the District's riparian shade program framework and riparian shade program implementation are presented in Chapters 5 and 6 of the TLMP.*

Table 1. Clean Water Services Plant Community Types within the Tualatin Basin

| Plant Community | Hydrology | Soils | Min. Map Unit (ac) | Sample Plant Associations[1] |
|---|---|---|---|---|
| Riparian Forest (RF) | within floodplain, occasionally flooded | hydric/ non-hydric | 0.50 | A. *Fraxinus latifolia-Thuja plicata-Populus trichocarpa-Physocarpus capitatus*<br>B. *Abies grandis-Acer macrophyllum-Alnus rubra-Mahonia aquifolium-Rosa pisocarpa* |
| Upland Forest (UF) | outside floodplain, only flooded during extreme events | non-hydric | 0.50 | A. *Pseudotsuga menziesii-Acer macrophyllum-Acer circinatum*<br>B. *Quercus garryana-Arbutus menziesii-Holodiscus discolor* |
| Forested Wetland (FW) | within floodplain, seasonally flooded, meets wetland criteria | hydric | 0.50 | A. *Fraxinus latifolia-Symphoricarpos albus/Cornus sericea/Rosa pisocarpa*<br>B. *Alnus rubra-Thuja plicata-Rubus spectabilis* |
| Emergent Wetland (EM) | within floodplain, seasonally flooded, meets wetland criteria | hydric | 0.25 | A. *Carex stipata-Carex unilateralis-Juncus ensifolius-Deschampsia cespitosa-Scirpus microcarpus*<br>B. *Sagittaria latifolia-Scirpus validus-Beckmania syzigachne-Leersia oryzoides* |
| Scrub-Shrub Wetland (SS) | within floodplain, seasonally flooded, meets wetland criteria | hydric | 0.25 | A. *Salix lasiandra-S. sitchensis-Spiraea douglasii-Cornus sericea*<br>B. *Physocarpus capitatus-Rosa pisocarpa-Malus fusca* |
| Oak Woodland (OW) | outside floodplain, upland | non-hydric | 2.5 | A. *Quercus garryana-Symphoricarpos albus-Rubus parviflorus-Rhamnus purshiana*<br>B. *Quercus garryana-Pinus ponderosa-Symphoricarpos albus-Acer circinatum* |
| Oak Savanna (OS) | outside floodplain, upland | non-hydric | 5.0 | A. *Quercus garryana-Rosa pisocarpa-Elymus glaucus- Camassia quamashB.*<br>B. *Quercus garryana-Symphoricarpos albus-Amelanchier alnifolia-Bromus vulgaris-Danthonia californica* |
| Wet Prairie (WP) | within floodplain, ponding during winter/spring | hydric | 0.25 | A. *Glyceria elata-Camassia quamash-Plagiobothrys figuratus-Hordeum brachyantherum-Eriophyllum lanatum*<br>B. *Danthonia californica-Deschampsia cespitosa-Lupinus polyphyllus-Potentilla gracilis-Sidalcea campestris* |

[1] Plant associations are neither comprehensive nor exclusive

iv. Project duration and useful lifetime expectancy, including: cumulative, annual, and seasonal practices;
*The District releases stored water from Hagg Lake and Barney Reservoir each year. Thermal credits from the stored water releases are calculated on a daily basis during July and August based on the temperature reduction above the WWTFs. Thermal credits from this activity would be available as long as the District continues to release stored water. Details of the flow enhancement program are described in Chapter 4 of the District's TLMP.*

*Riparian shade projects will deliver environmental benefits for several decades. The District conducts routine monitoring of site conditions and riparian shade to ensure that anticipated environmental benefits are being delivered. Projects are deemed to be successful as long as the environmental benefits (i.e., shade) at the site are documented and sustained. The District may adjust the credits based on project functionality or remove the project and associated thermal credits from its portfolio of riparian shade projects if the project is unsuccessful. If necessary, the District will substitute other non-credited (i.e., reserve) project sites to its portfolio of riparian shade projects.*

v. Factors affecting temporal performance such as time lag between BMP establishment and realization of water quality benefits; and

vi. Potential interactions with other practices;
*As noted above, the thermal credits from flow enhancement are derived based on the thermal benefits accrued above each WWTF using empirical equations that account for the stored water release rate and stream flow conditions. Location and attenuation factors are taken into account when calculating the thermal credits from flow enhancement activities.*

*The District applies a 2:1 trading ratio for calculating thermal credits from riparian shade projects. This means that twice as much thermal load will be blocked than is needed to offset the thermal load from the WWTFs. The trading ratio is primarily used to account for the time lag between initial planting and shade establishment, which was envisioned to be 20 years. The District's focus on conducting riparian shade projects on smaller tributary streams has resulted in a much shorter period for shade establishment. Additionally, the District intends to generate the necessary thermal credits to offset growth related increases in thermal load from the WWTFs before the anticipated growth occurs, further reducing the shade establishment period. Thus, the District's focus on smaller tributary streams where shade can be developed quickly, along with a strategy to develop thermal credits before they are needed, enables the District to reduce the time between initial planting and shade establishment to much less than the 20 years.*

*The District also undertakes significant steps to improve the success of its riparian shade program; these include developing a variety of land stewardship agreements, designing ecologically-appropriate planting plans, extending site preparation, conducting high density riparian shade plantings, implementing robust monitoring and maintenance programs, and conducting inter-planting as necessary to ensure project functions are achieved.*

vii. Identification of ancillary benefits and unintended consequences; and a description of conditions or risk factors where a BMP will not function (e.g., large storms);
*The District's trading program supports numerous ecosystem benefits beyond temperature benefits. Flow enhancement provides cooling effects, buffers against temperature changes, and results in higher dissolved oxygen levels and better overall water quality to support aquatic life. The release of stored water, along with the release of the highly treated water from the District's Rock Creek and Durham AWTFs, also provides a sustainable base flow to the mainstem Tualatin River during the dry season.*

*The ecosystem benefits of riparian shading activities include improved stream functions (e.g., floodplain roughness, bank stabilization, peak flow attenuation, habitat creation), increased diversity of aquatic and terrestrial plant and animal species, filtering of stormwater runoff, and improved water quality. The increased complexity of structure and diversity of restored riparian forests and scrub-shrub wetlands support many important ecosystem functions for the aquatic environment. One example is the colonization of some stream reaches by beavers, a keystone species for stream function in the Tualatin River watershed. By raising the water table, beavers promote floodplain wetlands with enhanced plant, animal, and geomorphic diversity. These features and the resultant geomorphic complexity enhance fish habitat quality and may also provide cold water refuges. Thus, the enhancement of riparian areas within and outside the District's service area improves the overall health of the Tualatin River watershed and creates partnerships with positive outcomes for water quality.*

*Additional details regarding ecosystem benefits of the District's flow enhancement and riparian shade programs is provided in Chapter 7 of the TLMP.*

*The District has developed programmatic tools to address many risks to credit effectiveness including strong partnerships with many community organizations, land preservation instruments or easements, land owner stewardship agreements, and contract provisions for liquidated damages. However, unforeseen events such as floods, fires, or other acts of God may result in a reduction in riparian shade across projects. The District may substitute another project from its reserve pool to address loss of riparian shade due to unforeseen events. If a reduction occurs and the District is not able to substitute with reserve riparian shade projects, the District and DEQ, with public input, will develop an action plan to address the loss of riparian shade due to unforeseen events.*

viii. BMP design criteria, including installation instructions; verifiable installation criteria (e.g., 100 foot minimum buffer width); qualitative installation criteria (e.g., fence material type); management instructions (e.g., seeding rate);
*The District's design criteria for the flow enhancement program is to provide sustainable base flows in the upper Tualatin River, maintain minimum dilutions for WWTF discharges, offset the thermal load from the District's WWTFs, and improve dissolved oxygen and overall water quality in the lower Tualatin River.*

*For the riparian shade program, the District utilizes a rapid riparian restoration strategy to generate shade cover quickly. Under this approach, the District targets wide buffers (up to 135-feet) well in excess of buffer widths necessary for thermal credits, establishes defensible site boundaries well beyond those necessary to generate thermal credits, conducts extended site preparation activities to increase the likelihood of project success, conducts ecologically appropriate plantings with a diverse plant community that are appropriate for the site, conducts initial plantings at very high densities (~2,500 stems per acre), and implements a robust monitoring and maintenance program to ensure riparian shade projects succeed. Additional details regarding the implementation of the riparian shade program are presented in Chapter 6 of the TLMP.*

ix. BMP monitoring criteria, and the specific metrics to be monitored to ensure the BMP is effective at reducing pollutants and installed correctly;
*The District, in collaboration with its partner agencies in the Tualatin River watershed, operates 19 stream flow monitoring stations in the watershed. Many of these monitoring stations provide near real-time flow data in the Tualatin River and key tributaries. The District uses this*

*information to manage its stored water releases and to ensure the effectiveness of its flow enhancement program.*

*At each riparian shade planting project, the District conducts baseline monitoring, routine monitoring, and shade monitoring to promote project success. Baseline monitoring is conducted prior to initial planting at the project site. Baseline conditions are assessed to serve as a benchmark for calculating the reduction in thermal load associated with the implementation of the riparian shade project. The District documents existing vegetation and other site characteristics (e.g., stream aspect, wetted width, and incision) by conducting field measurements and through the use of remotely sensed datasets, such as LiDAR and aerial photos.*

*The District conducts routine monitoring that consists of qualitative and quantitative assessments at all riparian planting projects. Monitoring is typically conducted during early fall prior to leaf drop. Qualitative monitoring is conducted on an annual basis and is used to assess overall project health and project phase. Quantitative monitoring is conducted every two years and includes information regarding native tree and shrub counts, species composition, stem density, and riparian structure (i.e., canopy).*

*Shade is monitored at all riparian project sites to assess the development of shade-producing canopy. Shade monitoring occurs five years following initial enrollment of the project for thermal credit and every five years thereafter until year twenty. A densiometer or remotely sensed datasets, such as LiDAR and aerial photos, are used to evaluate canopy cover and stream shade.*

*Additional information regarding the District's riparian shade monitoring protocols is provided in Chapter 6 of the TLMP.*

x. Description of BMP operation and maintenance requirements;
*As noted above, the District, in collaboration with its partner agencies in the Tualatin River watershed, operates 19 stream flow monitoring stations in the watershed. Many of these monitoring stations provide near real-time flow data in the Tualatin River and key tributaries. The District uses this information to manage its stored water releases and to ensure the effectiveness of its flow enhancement program.*

*With regards to its riparian shade planting program, the District applies a functional-based assessment process to determine if a riparian planting project is in a transitional, establishment, or stewardship phase. This assessment approach assists in determining the necessary level of ongoing maintenance needed for riparian planting projects (e.g., inter-planting, seeding, weed control, herbivore protections). This assessment methodology is designed to mimic the dynamic nature of riparian planting projects as they mature from initial plantings to stable riparian ecosystems.*

*The transitional phase is defined as the period between initial planting and plant establishment. Typically, this takes four to five (4-5) years and requires aggressive maintenance actions including herbivore protection, weed control and inter-planting. Criteria for transitioning the sites to the "establishment" phase are based on the plant community type and include target stem density, percent native aerial cover, and prevalence index (Table 2). Note that it is typical for stem densities to decrease from the transitional phase to the establishment phase. Depending on plant community type, the District typically targets stem densities of about 2,300 - 2,500 per acre at project sites with the goal of achieving a target stem density of 1,400 – 1,600 per acre in the establishment phase. Projects that do not meet the establishment criteria after five (5) years are evaluated and then modified as necessary to promote project success.*

*Table 2. Criteria for Transition from Transitional to Establishment Phase*

| Plant Community Type | Initial[2] Stems/Acre | Target Stems/ Acre | Native Aerial Cover (%) | Prevalence Index[3] |
|---|---|---|---|---|
| Emergent Wetland | NA | NA | ≥ 60 herbaceous | <3.0 |
| Scrub-Shrub Wetland | 2500 | ≥ 1600 | ≥ 60 woody | <3.0 |
| Forested Wetland | 2500 | ≥ 1600 | ≥ 60 woody | <3.0 |
| Riparian Forest | 2500 | ≥1600 | ≥ 60 woody | NA |
| Upland Forest | 2300 | ≥ 1400 | ≥ 60 woody | NA |
| Oak Woodland | NA | NA | ≥ 60 woody | NA |
| Oak Savanna | NA | NA | NA | NA |
| Wet Prairie | NA | NA | ≥ 60 herbaceous | <3.0 |

*The establishment phase is characterized by vigorous growth and reduced competition from non-native vegetation. Typically, the establishment phase takes two to three (2-3) years and requires a reduced maintenance level. Maintenance actions include herbivore protection, weed control and inter-planting. Once a project is deemed to be ecologically stable, it enters the stewardship phase where the maturing plant communities are monitored and maintained. The criteria for transitioning to the stewardship phase are presented in Table 3.*

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[2] 0.01 trees/sq. ft., 0.05 shrubs/sq. ft.

[3] The prevalence index is calculated using methods outlined in the 1987 USACOE Wetland Delineation Manual Supplements. When averaged across the plant community type, the prevalence index can provide a picture of the moisture tolerance of the wetland.

Table 3. Criteria for Transition from Establishment to Stewardship

| Plant Community Type | Invasive Species (%) | Composition/ Diversity /Structure (# native species) | Canopy | Native Aerial Cover (%) |
|---|---|---|---|---|
| Emergent Wetland | ≤ 20 | ≥ 5 herbaceous | NA | ≥ 90 herbaceous |
| Scrub-Shrub Wetland | ≤ 20 | ≥ 5 shrubs<br>≥ 3 herbaceous | ≥85 % | NA |
| Forested Wetland | ≤ 20 | ≥ 5 shrubs<br>≥ 3 trees<br>≥ 3 herbaceous | ≥85 % | NA |
| Riparian Forest | ≤ 20 | ≥ 5 shrubs<br>≥ 3 trees<br>≥ 5 herbaceous | ≥85 % | NA |
| Upland Forest | ≤ 20 | ≥ 5 shrubs<br>≥ 3 trees<br>≥ 5 herbaceous | ≥85 % | NA |
| Oak Woodland | ≤ 20 | ≥ 5 shrubs<br>≥ 1 trees<br>≥ 3 herbaceous | ≥85 % | NA |
| Oak Savanna | ≤ 20 | ≥ 1 trees<br>≥ 5 herbaceous | NA | ≥ 80 herbaceous |
| Wet Prairie | ≤ 20 | ≥ 5 herbaceous | NA | ≥ 80 herbaceous |

xi. BMP Quantification methods, including: units of measure; technical documentation of quantification approaches/tools, including assumptions and documentation of BMP implementation monitoring and effectiveness measurement accuracy and precision; alternative quantification approaches/tools; and effectiveness estimates, including justifications and references;
*As noted above, the District has developed empirical equations based on the 2001 Tualatin River Subbasin TMDL to quantify the thermal benefits of flow enhancement. The District uses the DEQ Shad-A-Lator model to quantify benefits from riparian shade projects. The approach and methodology are presented in Appendix A of the TLMP.*

xii. Objective and verifiable BMP performance criteria (e.g., no more than 20% cover invasive species) and procedures for documenting those results;
*See response to item x above.*

xiii. Credit calculation guidelines, including guidelines for: applying methodology to pre-project site conditions after trading baseline conditions are satisfied, measuring/predicting future conditions, and documenting assumptions and data used in quantifying water quality benefits;
*Thermal credits calculation methodology for the flow enhancement program and riparian shade program are presented in Chapters 4 and 5 of the TLMP, respectively.*

xiv. Ratio considerations, including a description of the types of ratios that might apply to the BMP and under what circumstances; and
*The District applies a 2:1 trading ratio for calculating thermal credit for riparian shade projects. This means that twice as much thermal load will be blocked than is needed to offset the thermal load from the WWTFs. Chapter 5 of the TLMP includes a discussion of the trading ratio.*

xv. Citations of scientific journals or reports from which the BMP quality standards or guidelines were derived.
*A number of scientific journal articles have been written regarding the effectiveness of riparian shade in addressing stream temperature issues. Here is a brief sampling of the articles:*

Bowler, D.E., R. Mant, H. Orr, D.M. Hannah and A.S. Pullin. 2012. What are the effects of wooded riparian zones on stream temperature? *Environmental Evidence* 1:1-9.

Burbidge, A.H., M. Maron, M.F. Clarke, J. Baker, D.L. Oliver and G. Ford. 2011. Linking science and practice in ecological research and management: How can we do it better? *Ecological Management & Restoration* 12(1):54-60.

Butler, S. and J. Long. 2005. Economics and Survival of Hand-Planted Riparian Forest Buffers in West Central Maine. U.S. Department of Agriculture, Natural Resource Conservation Service.

Carter, K. 2005. The effects of temperature on steelhead trout, Coho salmon, and Chinook Salmon biology and function by life stage: implications for Klamath basin TMDLs. California Regional Water Quality Control Board, North Coast Region.

Christy, J.A. and E.R. Alverson 2011. Historical vegetation of the Willamette Valley, Oregon, circa 1850. *Northwest Science* 85:93-107.

Fierke, M.K. and J.B. Kauffman. 2006. Invasive species influence riparian plant diversity along a successional gradient, Willamette River, Oregon. *Natural Areas Journal* 26:376-382.

Guillozet, P., K. Smith and K. Guillozet. 2014. The Rapid Riparian Revegetation Approach. *Ecological Restoration* 32(2):113-124.

Lancaster, S., R. Haggerty, S. Gregory, K.T. Farthing, L. Ashkenas and S. Biorn-Hansen. 2005. Investigation of the temperature impact of hyporheic flow: using groundwater and heat flow modeling and GIS analysis to evaluate temperature migration strategies on the Willamette River. Oregon State University, Corvallis, OR.

Seavy, N.E., T. Gardali, G.H. Golet, F.T. Griggs, C.A. Howell, R. Kelsey, S.L. Small, J.H. Viers and J.F. Weigand. 2009. Why climate change makes riparian restoration more important than ever: Recommendations for practice and research. *Ecological Restoration* 27:330-338.

Suding, K.N., K.L. Gross and G. Houseman. 2004. Alternative states and positive feedbacks in restoration ecology. *Trends in Ecology and Evolution* 19:46-53.

Sweeney, B.W. and J.D. Newbold. 2014. Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: a literature review. JAWRA 50:560-584. doi:10.111/jawr.12203.

Weisberg, P.J., S.G. Mortensen and T.E. Dilts. 2012. Gallery Forest or Herbaceous Wetland? The Need for Multi-Target Perspectives in Riparian Restoration Planning. *Restoration Ecology* 21(1):12-16.

Withrow-Robinson, B., M. Bennet and G. Ahrens. 2011. A Guide to Riparian Tree and Shrub Planting in the Willamette Valley: Steps to Success. Oregon State University Extension.